UCRL-JC-125988 Abs & Sum

Evaluation of Smoothing by Spectral Dispersion on the Beamlet Laser for the National Ignition Facility

Joshua E. Rothenberg, Bryan Moran, Mark Henesian,

and Bruno Van Wonterghem

Lawrence Livermore National Laboratory, L-439

P. O. Box 808, Livermore, CA 94551

Phone: (510) 423-8613, FAX: (510) 422-5537

Email: JR1 @ LLNL.GOV

Abstract: Simulations indicate that SSD results in a slight degradation to the near field beam quality. Ongoing measurements show no degradation to the near field beam and the expected improvement in far field speckle contrast.

This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

Evaluation of Smoothing by Spectral Dispersion on the Beamlet Laser for the National Ignition Facility

Joshua E. Rothenberg, Bryan Moran, Mark Henesian,
and Bruno Van Wonterghem

Lawrence Livermore National Laboratory, L-439
P. O. Box 808, Livermore, CA 94551
Phone: (510) 423-8613, FAX: (510) 422-5537
Email: JR1 @ LLNL.GOV

Inertial confinement fusion (ICF) utilizing direct or indirect laser drive requires the target illumination to be uniform over a wide range of spatial frequencies. A number of approaches have been suggested to achieve the desired level of illumination uniformity.[1-4] Angular dispersion of phase modulated (FM) light (termed smoothing by spectral dispersion - SSD)[4] is attractive for ICF using glass lasers, since pure phase modulation preserves the uniform intensity profiles necessary for high power laser amplification. 1D SSD has been demonstrated on the NOVA laser,[5] however the National Ignition Facility (NIF) will require much more efficient and reliable operation. Therefore, it is of interest to investigate the performance of 1D SSD on the Beamlet laser, which is a NIF prototypical multipass laser system.

Numerical simulations of the Beamlet laser using PROP92 have been performed for the case of a 12 kJ, 3 ns pulse with ±200 μrad main cavity spatial filter pinholes. These simulations show that the critical parameter for the laser performance is the amount of additional divergence imposed on the beam by SSD in comparison to the size of the spatial filter pinholes. Figure 1 shows the results of the PROP92 calculations for the integrated far field fluence just before the transport spatial filter pinhole (after all amplification) at increasing amounts of SSD. One sees that a characteristic FM spectrum appears riding on a noise floor (owing to aberrations and nonlinear growth). As the SSD divergence increases, the relative size of the noise floor to the far field peak increases, and the drop off at ± 200 mrad decreases. This increased clipping of energy at the pinhole edges leads to increased near field modulation owing to Gibbs related phenomena and associated nonlinear growth. The PROP92 simulations show that the near field contrast increases from 12% without SSD to 14% with 50 mrad of SSD, and the peak to average ratio increases from 1.7 to 1.8. This very slight degradation of the beam quality becomes more severe at larger SSD divergence. For 100 mrad of SSD the contrast increases to 17% and peak to average increases to 2.1. However, for the levels of SSD anticipated on the NIF (~ 25 mrad for indirect drive), the beam quality degradation is quite small. Measurements with low power front end amplifier shots show no near field beam degradation for divergence of up to 100 mrad. The high power performance of the Beamlet laser will also be reported.

Figure 2 shows measurements of smoothing of speckle in the far field using the Beamlet preamplifier beam. The saturated horizontal structures are an artifact of this measurement, and the contrast of the smoothed speckle is determined outside of this region. Although the resolution of the CCD camera is adequate the 50% measured contrast of the static speckle pattern is less than the expected 100%. Nevertheless, the improvement in contrast in the smoothed images relative to the static contrast (from 50% to as little as 15% for 100 mrad SSD divergence) is correctly predicted by simulations.

This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

References

1. R. H. Lehmberg and S. P. Obenschain, Optics Comm. **46**, 27 (1983) and R. H. Lehmberg and J. Goldhar, Fusion Technology **11**, 532 (1987).

2. Y. Kato *et al*, Phys. Rev. Lett. **53**, 1057 (1984).

3. D. Véron *et al*, Optics Comm. **65**,42 (1988).

4. S. Skupsky *et al*, J. Appl. Phys. **66**, 3456 (1989).

5. D. M. Pennington et al, Proc. Soc. Photo-Opt. Instrum. Eng. **1870**, 175 (1993).

Figure Captions

Figure 1: PROP92 calculations showing the integrated far field intensity just before the transport spatial filter pinhole plane, for a 12 kJ, 3ns pulse with ±200 mrad pinholes, and with the indicated amount of SSD divergence.

Figure 2: Smoothing of far field images of the preamplifier beam focused through a random phase plate with varying amounts of SSD. The saturated foci and emanating horizontal stripes are an experimental artifact. (a) static speckle, without SSD, and contrast = 50%; (b) SSD modulation depth 1.4, total divergence 9 mrad, 1 color cycle, and contrast = 26%; (c) depth 3.8, 25 mrad, 1 color cycle, and contrast = 20%; (d) depth 6.7, 100 mrad, 2.5 color cycles, and contrast = 15%. The white bar at the bottom of each image corresponds to a far field angle of 100 mrad (scaled relative to the full beam size of 35 cm).

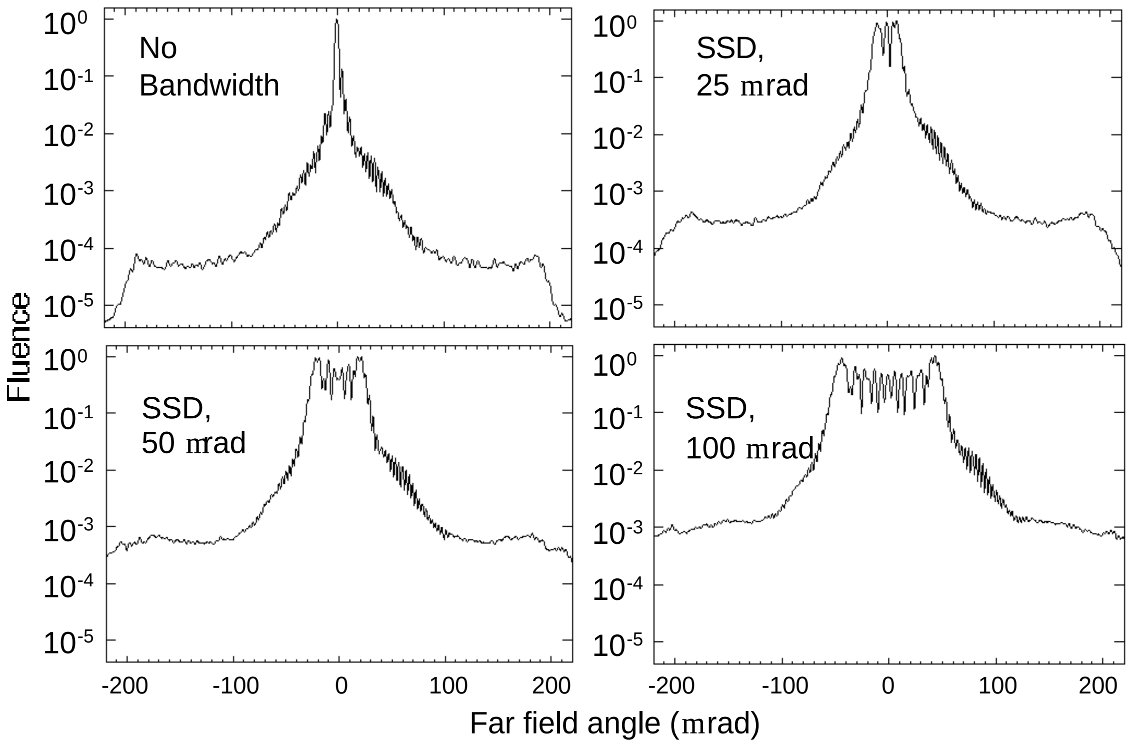

Figure 1: PROP92 calculations showing the integrated far field intensity just before the transport spatial filter pinhole plane, for a 12 kJ, 3ns pulse with ±200 mrad pinholes, and with the indicated amount of SSD divergence.

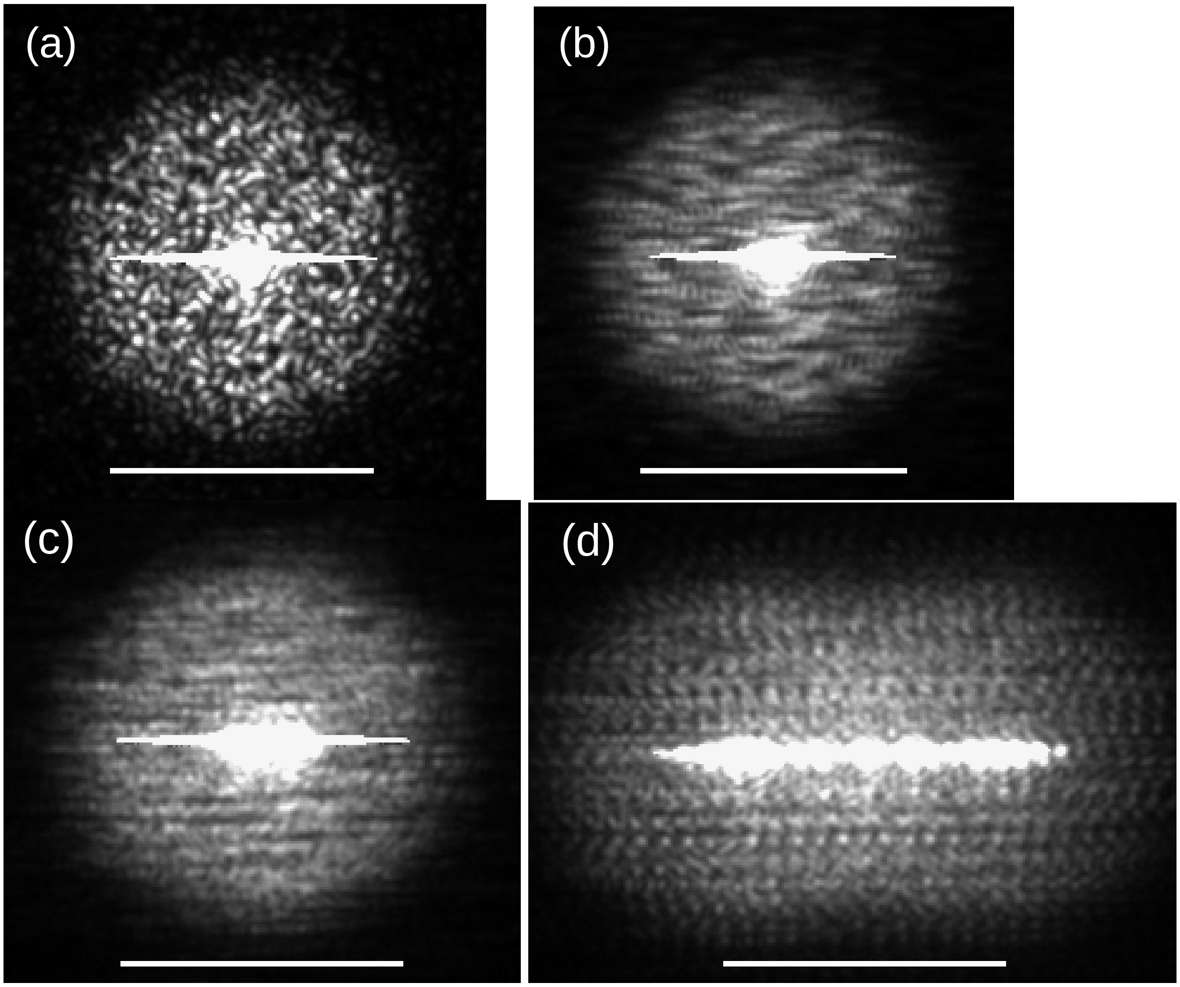

Figure 2: Smoothing of far field images of the preamplifier beam focused through a random phase plate with varying amounts of SSD. The saturated foci and emanating horizontal stripes are an experimental artifact. (a) static speckle, without SSD, and contrast = 50%; (b) SSD modulation depth 1.4, total divergence 9 mrad, 1 color cycle, and contrast = 26%; (c) depth 3.8, 25 mrad, 1 color cycle, and contrast = 20%; (d) depth 6.7, 100 mrad, 2.5 color cycles, and contrast = 15%. The white bar at the bottom of each image corresponds to a far field angle of 100 mrad (scaled relative to the full beam size of 35 cm).